on December 14. A few other cases of local magnetic fields, casually encountered before this systematic search was undertaken, occur in our records.

The field-strengths observed, from 200 to 500 gausses, are of the same order as those of the smallest visible spots.

GEORGE E. HALE.

SUMMARY OF MOUNT WILSON MAGNETIC OBSERVATIONS OF SUN-SPOTS FOR NOVEMBER AND DECEMBER, 1921

In the opening number of a new volume of these PUBLICATIONS it seems desirable to recapitulate the methods of observation and the scheme of classification underlying these tables. Reference must also be made to the inclusion hereafter of local magnetic fields, or invisible spots, which are described in a separate note.

Systematic observations of the magnetic polarities of sun-spots have been made daily with the 150-foot tower telescope since 1915. Summaries of the results have appeared regularly in these PUBLICATIONS since May, 1920, and preparations are being made for detailed publication, in graphical form, of the entire set of daily records.

The image of the Sun, 42.4 cm. in diameter, is projected upon a sheet of paper and a sketch of the spots is made. The approximate heliographic latitude and longitude of each group is read from a disk upon which the meridians and the parallels of latitude have been drawn. The magnetic polarity and approximate field-strength of each spot are then determined by the character of the polarization and the measured separation of the components of the Zeeman triplet λ6173.553 (Fe), observed in the second order spectrum of the 75-foot spectrograph.

The large solar image permits the polarities of very small spots to be determined, but since the lines of force at the center of a spot are generally normal to the Sun's surface, polarity observations are difficult for large spots and impossible for small ones when near the limb.[1] Local magnetic fields, or invisible spots, are also observed regularly whenever possible. In this

[1]For further details see *Mt. Wilson Contr.*, No. 165, *Ap. Jour.*, April, 1919.

way the life of a spot is often considerably prolonged, either by the appearance of the magnetic field before the visible stage, or its persistence after the spot has disappeared. (See notes accompanying tables.)

For convenience of reference each spot group is given a serial number (col. 1 of the accompanying tables). While we should prefer to use the Greenwich numbers this has not been feasible, partly because of the interruption in their publication during the war, and also because our magnetic scheme must frequently bring into a single group spots that would otherwise be classed separately, or *vice versa*. The last published Greenwich number, No. 7930, was No. 511 of the Mount Wilson series.

In order to make identification possible, the Greenwich mean time of central meridian passage and the heliographic latitude are given for each group in the second and third columns of the tables. These positions are approximate and may differ somewhat from the measured values obtained at Greenwich. Column 4 gives the approximate maximum field-strength, H, observed in each group, expressed in units of 100 gausses.

The spot groups are divided into three classes, which are designated here as *unipolar, bipolar,* and *complex*.

Unipolar groups are single spots or groups of spots having the same magnetic polarity. This class is subdivided, according to the position of the group in the surrounding calcium flocculi, as follows:

(*a*) Those for which the distribution of calcium flocculi is fairly symmetrical preceding and following the group.

(*ap*) Those which are followed by a distinctly elongated mass of calcium flocculi.

(*af*) Those which are preceded by a distinctly elongated mass of calcium flocculi.

The simplest *bipolar* group consists of two spots of opposite polarity, the line joining them generally making a small angle with the solar equator. Usually, however, the *bipolar* group is a stream of spots, those in the preceding and following parts of the group being of opposite polarity. Generally the change in polarity is near the center of the stream, but it may be on either side of the center. *Bipolar* groups are subdivided, according to

the area and distribution of the different magnetic fields, as follows:

(β) Those in which the preceding and following members, whether single or multiple, are approximately equal in area.

(βp) Those in which the preceding member is the principal component of the group.

(βf) Those in which the following member is the principal component of the group.

($\beta\gamma$) Those in which the bipolar characteristics are shown, but in which there is no marked dividing line between the spots of different polarities. This includes cases where the preceding or following members are accompanied by companions of opposite polarity.

Rigorously defined, the principal component of a bipolar group, whether single or multiple, is that for which the total integrated field-strength is the greater. In daily practice it would be almost impossible to make a sufficient number of measures of field-strength and area to determine this quantity accurately. Up to a certain area, the field-strength is almost directly proportional to the diameter of the spot, with its maximum intensity near the middle of the umbra, decreasing to zero just beyond the outer edge of the penumbra. But when the spot is split up into several members, the maximum field-strength in any one of them is much below that shown by an unbroken spot. Accordingly, in a bipolar group consisting of a large single spot followed by several smaller spots having the same total area, the preceding spot would be regarded as the principal component. The integrated field-strength as thus estimated, not actually measured, serves sufficiently well for classification purposes.

On account of the greater difficulty of detecting invisible spots, especially when the seeing is poor, their presence is not indicated in the tabulated classification, but they are recorded in the notes.

The *complex* groups (γ) are those in which spots of both polarities are so irregularly distributed as to prevent classification as *bipolar* groups. The class is small but contains many of the large, very active groups. It should be noted, however, that unipolar spots and the chief components of *bipolar* groups may

MAGNETIC CLASSIFICATION OF SUN-SPOTS FOR NOVEMBER, 1921

No.	C. M. P.	Lat.	H	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1915	Oct. 27.4	+4	34	*ap*	*x*													
1917	Nov. 17.8	+8	30												*ap*	*ap*	*ap*	
				1	1	0	0	0	0	0	0	0	0	0	1	1	1	—

No.	C. M. P.	Lat.	H	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1917	Nov. 17.8	+8	30		*ap*	*ap*	*ap*	*ap*	*ap*	*βp*	*βp*							
1918	23.2	+5	22		*x*	*x*	*ap*	*ap*	*ap*	*ap*	*ap*		*ap*	*ap*	*ap*	*ap*		
1919	24.4	−7	31			*x*	*βp*	*βp*	*βp*	*βp*	*βp*		*βp*	*ap*	*ap*	*ap*		*x*
1920	Nov. 18.5	+8	10							*β*	*β*							
				—	2	3	3	3	3	4	4	—	2	2	2	2	—	1

NOTES

No. 1917. Return of No. 1914.

No. 1918. Return of No. 1915.

No. 1919. The small positive spots which comprised the following members of this group had disappeared on Nov. 26, but a measurable magnetic field was still present on Nov. 26 and 27 in the position where they had been.

No. 1920. A small bipolar group closely following the large regular spot No. 1917. On Nov. 19, 20, and 21 a small negative magnetic field was detected in the position of the following spot of No. 1920 which appeared on Nov. 22. About 5° south of this region another magnetic field, with no visible spot, was observed on Nov. 19 and 20.

MAGNETIC CLASSIFICATION OF SUN-SPOTS FOR DECEMBER, 1921

No.	C. M. P.	Lat.	H	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1921	Dec. 2.2	+10	*x*			*x*												
1922	Nov. 30.2	−10	*x*		*x*													
1923	Dec. 10.0	−12	*x*					*x*	*x*									
1924	15.1	+10	22									*x*	*ap*	*ap*	*ap*	*ap*	*βp*	*ap*
1925	15.0	+ 6	27									*af*	*af*	*βf*	*βf*	*βf*	*βf*	*βf*
1926	10.5	+ 9	16										*β*	*β*	*β*	*β*	*x*	
1927	15.0	+10	5													*βγ*	*x*	
1928	Dec. 21.2	− 6	26															*x*
				0	1	1	0	1	1	0	0	2	3	3	3	4	4	3

No.	C. M. P.	Lat.	H	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1924	Dec. 15.1	+10	22	*βp*	*x*														
1925	15.0	+ 6	27	*βf*	*x*														
1928	21.2	− 6	26	*ap*	*x*					*x*									
1929	18.0	+12	*x*		*x*												*x*		
1930	Dec. 29.4	+11	*x*																
				3	4	—	—	—	—	1	—	—	—	—	—	—	1	0	—

NOTES

No. 1924. Return of No. 1917. On Dec. 12 and 13 it was followed by weak magnetic fields which did not show as spots until Dec. 14.

No. 1925. A very active group just south of No. 1924.

No. 1927. A small group in the same disturbed region as Nos. 1924 and 1925. The group consisted of two or three negative spots directly south of a positive spot.

No. 1928. Return of No. 1919.

occasionally have small companions of opposite polarity, which play such a minor and sporadic part in the group that they are disregarded in the classification.

In the tabulation of the polarities an *x* indicates that the group was photographed or seen on that date, but that no polarity observation was made of it. The direct photographs taken with the 60-foot tower telescope are available for these additional data. At the foot of each column is given the number of groups observed that day. When the column for any day is blank, and a dash is used instead of the number of groups, it indicates that no observations were made on that date. If the Sun was observed but no spots were visible, a zero will be found at the foot of the daily column.

Since the minimum of 1913, *unipolar* groups and the preceding spots of *bipolar* groups in the northern hemisphere have had a polarity like that of a north-seeking pole, called positive in this summary. In the southern hemisphere similar spots are of opposite polarity, and are called negative. There are very few exceptions to this rule, and unless the contrary is noted it is to be understood that the group is "regular" in polarity.

Sun-spot Activity During 1921

During the present year 140 sun-spot groups have been observed at Mount Wilson, 73 north and 67 south of the solar equator. Compared with the 295 groups observed in 1919 and the 168 in 1920, this indicates a less rapid decrease in spot activity than that hitherto characteristic of this cycle. The movement of the spot zones toward the Sun's equator has continued at the normal rate. The average distance of all spots from the equator was 10°.0, the average latitude in both hemispheres being the same.

The greatest number of separate groups observed on a single day was eight, on July 2. There were 31 days on which no spots were visible, a decided increase from the eight spotless days of 1920. Most of these spotless days were in the last five months of the year, nine of them being in the month of November. During these months one hemisphere of the Sun remained practically free from spots, so that when the solar rotation